PATENT SPECIFICATION

DRAWINGS ATTACHED

844,536

Date of Application and filing Complete Specification May 8, 1957.

No. 14702/57.

Application made in France on Jan. 7, 1957.

Complete Specification Published Aug. 10, 1960.

Index at acceptance:—Classes 3(2), D1(D1:F); 87(2), A1R14(C3:D); 93, D(2A:2C:2D:6); and 140, A(1A:2C:2P:5B:6:11B:11C:11D3:11F:12), G, H.

International Classification:—B33d, j. B44d. D04j.

COMPLETE SPECIFICATION

Process and Apparatus for the Continuous Production of Flexible Webs

We, SOCIETE ANONYME DES PNEUMATIQUES DUNLOP, a French body corporate, of 64, rue de Lisbonne, Paris, France, and NOEL NEBOUT, a citizen of France, of Rue due Diënat, Montlucon, Allier, France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a process and apparatus for the continuous production of flexible webs.

In many industries, it is an advantage to be able to produce webs comprising one or more assemblies of fibres, filaments or strips, sometimes associated with composite materials, these webs not necessarily having their edges parallel to the direction of the filaments or strips of the component assemblies.

The present invention has for its object to render possible the continuous and simultaneous production of webs of equal or different widths formed of composite materials which are relatively flexible, at least at the time of their assembly. It is possible by means of the invention to produce at high rates of a different order from those of weaving looms, webs comprising more especially textile fibres, for example one or more layers of parallel fibres, filaments or strips, these filaments or strips extending at arbitrary angles with respect to one another and with respect to the longitudinal edges of the webs. The invention also permits the association of these elements with other flexible materials, notably plastic materials, which may constitute elements for the connection of the textile or other filaments or strips.

According to one aspect of the invention there is provided a process for the continuous production of flexible webs by continuously covering with a layer of material the periphery of a mandrel consisting of a plurality of elements assembled end-to-end, the said mandrel being moved longitudinally, and cutting the said layer of material to produce a web, wherein the said mandrel elements are cylindrical in shape and co-axially aligned to form a rectilinear mandrel of cylindrical formation between the point where the mandrel is covered and the point where the layer is cut, and wherein the mandrel is moved helically about its axis, the front element being periodically detached from the mandrel and an element being periodically attached to the rear end thereof.

According to another aspect of the invention there is provided apparatus for the continuous production of webs comprising a plurality of cylindrical elements of equal diameter, means for assembling the said elements end-to-end to form a cylindrical mandrel, means for moving said mandrel translationally along its longitudinal axis and also for rotating it about its axis, means for completely covering with a layer of material the surface of the said mandrel at the rear end with respect to the direction of its advance, means for cutting the said layer near to the forward end of the mandrel in order to detach the layer in the form of at least one web, and means for periodically detaching the front element from the mandrel and attaching an element to the rear end thereof.

The mandrel elements emanating from the front end of the mandrel may be stored for various subsequent treatments, while the mandrel elements attached to the rear part may emanate from a storage means, the stock accumulated at the front being periodically fed to the rear storage means.

Preferably, the mandrel element added to the rear end of the mandrel is the element which has just been detached from the front

[*Price 3s. 6d.*]

end, which is conveyed, preferably automatically, towards the rear part.

It is advantageous to construct the apparatus in such manner that the axis of the mandrel is horizontal in order that the advance of the mandrel may take place along this horizontal axis, whereby the conveyance of successive elements in a continuous chain from one end of the mandrel to the other may be simplified. Nevertheless, the apparatus may be so arranged that this axis occupies in space any vertical or inclined position.

Preferably, the stripping of the mandrel is effected by cutting the covering along at least one helix, so as to obtain a web which is tangentially detached from the said mandrel. There is thus directly obtained a plane web having rectilinear edges which may be, for example, wound on a bobbin.

It is also possible to cut this covering along another line determining a web of curved transverse section and to bring this web into the plane form by applying it against a roller (or between rollers) for unwinding the said web after its separation from the mandrel.

The arrangement of imparting a helical movement to the mandrel affords various advantages. More especially, it permits the covering of the mandrel by winding thereon a layer or sheet of parallel filaments (if desired agglomerated) emanating from a fixed installation.

It also permits the stripping of the mandrel by detaching cut webs therefrom along one or more helices having the same pitch as the said helical movement, so that these webs are separated from the mandrel in the manner of a continuous shaving along a straight line fixed in space, which permits one to use the webs immediately having previously to wind them on reels or bobbins.

For covering the mandrel, any of the known covering methods may be employed which are applicable to a cylindrical rotary body. For example, the covering may be entirely effected by spraying or painting material on the periphery of the mandrel.

More especially, the application of the fibrous reinforcements to the said mandrel may be carried out by means of conventional devices employed for the covering of tubes and of electric cables or the like, which permit of winding strips, filaments or webs on the said cables.

This application of coverings may be completed by means for connecting the said reinforcements together by an adhesive applied to the mandrel by spraying or winding in the form of an adhesive film.

The union between the reinforcements themselves and/or between the coverings and the adhesive products may be effected by heating and/or pressure. The heating may be external, the vehicle for the heat being a fluid, radiation or convection. The pressure may be produced with the aid of rollers applied against the periphery of the mandrel. These rollers may also be arranged for the transmission of heat.

The mandrel itself may be arranged for the application of a heat-treatment to the covering applied thereto. More especially, the sections may be arranged to receive a heating or cooling fluid, or the said mandrel may be heated by electric resistors incorporated in the assembled elements.

The end-to-end assembly of the various cylindrical elements constituting the mandrel may be effected either by providing on the ends of each element assembly means cooperating with one another, for example by interengagement or, preferably, by means of an assembly member common to the various elements and consisting of a spindle or a plurality of spindles extending through the elements to be assembled, whereby it is possible to produce mandrels of great length comprising a large number of assembled elements without danger of deformation of the said mandrels.

The two means of assembly may also be advantageously combined, each element being connected to the element on either side thereof by one or more spindles extending through all the elements.

More especially, the said spindle may with advantage be axial and may be provided with a longitudinal screwthread, so that it is possible by screwing the said spindle into axially located nuts in the said mandrel sections to connect the mandrel sections longitudinally on the said spindle.

In this case, the spindle may be prevented from moving longitudinally by devices alternatively engaged with each of its ends, the longitudinal advance and the rotation of the mandrel being effected by relative rotation of the said spindle and of the mandrel elements mounted thereon. The devices which come into engagement with the ends of the spindle may be rotary for effecting rotation of the said spindle.

In all cases, in order to permit a truly continuous production, that is to say, without any large time lag between the covering and the stripping of the mandrel, the overall length of the said mandrel is made greater than the distance occupied, along the said mandrel, by the covering and stripping devices; and in addition two devices controlling the advance of the said mandrel are arranged to become operative alternatively at each of the ends of the said mandrel, in order to make it possible, while the position of the mandrel is controlled at its rear end, to detach the front section of the mandrel and thereafter, while the position in turn is controlled at the front end, to connect to its rear end

a mandrel section emanating from the front portion of the mandrel.

By varying the diameter of the mandrel employed, the number of webs which are detached therefrom, and the angle chosen for cutting the covering from the said mandrel, it is possible to produce webs of any width, for example ranging from a few millimetres to several metres.

By way of example, the preparation of the following webs may be envisaged:—

1) Webs comprising one or more layers of parallel filament or fibres oblique in relation to the edges of the webs associated with materials such as viscose, or any other porous or non-porous plastic material. More especially, webs may be produced which comprise at least three layers of superposed interconnected filaments or fibres, the directions of the filaments of these layers intersecting one another so as to form a non-deformable triangulated system.

2) Webs consisting of skins or films of different nature or colour wound on the mandrel in overlapping fashion, so that the final web consists of different juxtaposed zones oblique in relation to the edges of the web. Such webs may have, for example, decorative applications.

3) Finally, webs consisting of fibres or segments of fibres or filaments extending in any direction, matted and agglomerated by a binder, the covering of the core being effected, if desired, by spraying and blowing of fibres and of the binder against the core.

The invention is illustrated, merely by way of example in the accompanying drawings in which:—

Figure 1 is a diagram illustrating the principle of the invention,

Figures 1*a*, 1*b* and 1*c* show diagrammatically devices for the circulation of the mandrel elements from the front of the mandrel to the rear,

Figure 2 shows in diagrammatic longitudinal section a first simple embodiment of an apparatus according to the invention,

Figure 3 is a section along the line III—III of Figure 2,

Figure 3*a* shows an enlarged detail of Figure 3,

Figure 4 is a view along the line IV—IV of Figure 2,

Figure 5 is a section along the line V—V of Figure 2,

Figures 6*a* and 6*b* are diagrammatic views of devices for cutting the covering,

Figure 7 is a diagrammatic view of a modified form of the stripping of the mandrel,

Figure 8 is a diagrammatic overall sectional view of an apparatus according to the invention employing a screwthreaded spindle for the assembly of the sections.

Figure 9 is a view along the line IX—IX of Figure 8,

Figure 9*a* shows a modification of Figure 9,

Figure 10 is an enlarged view of a modification of the construction shown in the left-hand part of Figure 8,

Figure 11 is a diagrammatic view of the device for driving that part of the apparatus which is shown in Figure 10.

Referring to Figure 1, a cylindrical mandrel of M diameter d consists of any number of cylindrical sections M_1 to M_6, for example, preferably of equal lengths. The mandrel M is rotatably mounted by means not shown for advance in the direction of its axis, as indicated by the arrow F. In its rear part (towards the right), it is provided with a covering which progressively occupies all its surface.

For this purpose, there may be helically wound on the said mandrel (in either direction) a number of webs such as A_1, A_2 . . . . A_n, either by rotating about the rotating mandrel a rotary device carrying strips, webs or filaments wound on bobbins, or by using webs emanating from any fixed device, which are wound onto the mandrel during the helical advance of the mandrel.

The webs A_1, A_2, etc. which have been wound on the mandrel in this manner have their helical edges contiguous if, for example, in the case of the web A, of width a_1 the pitch p_1 and the winding angle α_1 are such that $a_1 = p_1 \sin \alpha_1$.

The wound webs need not have their edges contiguous, or two webs of different nature wound in the same direction with the same pitch may overlap. Any combination of wound webs may be employed provided that at the end of these windings the surface of the mandrel is completely covered.

The covering thus formed is then cut on the mandrel along at least one helix S. A web B is thus detached from the cylinder, which is thereby completely bared, the width b of the said web being $b = p \sin \alpha$, where p is the pitch of the helix S and α the unwinding angle.

It is also possible to cut the covering of the cylinder along a number of helices S_1, S_2, etc. . . . parallel to the helix S, which gives webs B_1, B_2, B_3, etc. . . the sum of the widths of which is equal to that of the web B and which may be detached at different points of the mandrel.

The cutting of the covering and the unwinding of the webs obtained are obviously effected by the relative rotational movement of the cutting and unwinding members in relation to the mandrel in accordance with tthe movement of the latter.

Assuming now that the webs A_1 and A_2 are reinforced with filaments parallel to their edges, these filaments also form the winding angles α_1 and α_2 with the generatrices of the mandrel. If these webs A_1 and A_2 are wound in contiguous relationship, the result-

ant web B comprises, uniformly distributed over its surface, filaments emanating from the webs A_1 and A_2 and forming the angles β_1, β_2 respectively with the edges of the web B.

It will readily be seen that the angles β_1 and β_2 are the sum or the difference (depending upon the winding direction of the webs such as A_1 and A_2) of the unwinding angle α of the helix S and of the winding angles α_1 and α_2 of the webs A_1 and A_2.

By an appropriate choice of these various angles, it is thus possible to obtain directions of reinforcement at arbitrary angles in relation to one another and in relation to the edges of the web.

As the mandrel M advances in the direction of the arrow F, the front section M_1 clears the space used for the stripping of the mandrel, while the section M_6 advancing towards the left can no longer serve as a support for the covering device, which does not follow the advance of the mandrel.

In order to ensure continuity of production, it is desirable to separate the section M_1, which is no longer required, at the front of the mandrel and to add to the rear a section completing the usable length of the mandrel. More especially, the section M_1 itself can be conveyed along the path represented by the line T to the rear portion of the mandrel, and may be re-assembled with the rear of the section M_6.

Thus, the sections of the mandrel must be separated *seriatim* in a continuous chain from the front portion and brought to the rear.

A number of possible methods of effecting this continuous chain circulation are illustrated in the diagrammatic Figures 1*a* to 1*c*.

In the case of Figure 1*a*, the axis of the section M_1 at any one instant remain parallel with its axis at any other instant. In moving from the front to the rear end of the mandrel each element is displaced along a path which forms three sides of a rectangle, the fourth side of which is constituted by the mandrel, thus each element first performs a translational movement perpendicular to the axis of the mandrel, which brings it to M^1_1, then another translational movement parallel to the axis of the mandrel, which brings it to M^{11}_1, and then a third translational movement, parallel to the first but of opposite direction, which brings it to M^{111}_1 at the rear of the mandrel.

This triple translational movement may be effected by many mechanisms, of which two examples will hereinafter be described.

In the case of Figure 1*b*, the section M_1 follows a curved path C, which may be of any form, but which, since it includes the two ends of the mandrel, obliges each section to perform a complete revolution about its own axis, that is to say, always to be presented with its front face opposite the rear face of the mandrel. Such a path may be formed by rails (or a mono-rail), on which carriages supporting the sections are moved.

This path could if desired be formed by a curved bar, on which the mandrels are strung, this bar being supported by the sections themselves in contact with tracks for propelling rollers, or by clips opening to permit the passage of each successive section. A number of sections, such as M_1, M_m, M_n, M_p, M_r may in this case circulate along the same path.

Finally, the path C may be formed by flexible elements permanently connecting all the sections in a continuous string. The sections constituting the mandrel at a given instant are assembled by rigid members. The said flexible connecting means may if desired be chains of universal joints.

In accordance with a modified embodiment as shown in Figure 1*c*, the sections detached from the front may be conveyed and returned with a complete revolution with the aid of an articulated arm br-br^1 gripping the detached section M_1 and bringing it to M^1_1. Each of the parts of the articulated arm performs substantially a half-revolution, so that a complete revolution is effected by the conveyed section. The articulated arm may be actuated with a reciprocating motion, or it may always turn in the same direction.

The continuity of the covering and stripping operations, that is to say, the absence of any interruption in the advance of the mandrel, will be obtained if, despite these successive transfers of the mandrel sections from the front to the rear, the said mandrel always has sufficient length to permit the action of the covering and stripping devices.

To this end, the total length of the mandrel must be greater than the distance occupied, along the said mandrel, by covering and stripping devices, to the extent of the distance by which the mandrel advances, in the direction of the arrow F, during the operations of detaching the front section, if desired conveying this section to the rear and positioning a section at the rear of the mandrel, since the attaching and detaching operations cannot be simultaneous if it is desired permanently to control the position of the mandrel by one of its ends.

The apparatus illustrated in Figures 2 to 6*b* comprises examples of simple mechanism permitting one to obtain the various results described with reference to Figure 1.

In the apparatus illustrated in these figures, the mandrel M is centred and supported by the tubular guides 1 and 2, of which the first, in the illustrated example, also serves as a support for the stripping device. In order to reduce friction, to ensure accurate centering and to facilitate adjustment of the guiding diameter, the mandrel is supported in the said guides by rollers 3, each of which

lies in a plane corresponding to the direction of the relative movement of the guide and of the mandrel.

Some of the said rollers 3, which are coated with rubber, may be used to ensure the advance of the mandrel. For this purpose, the driving rollers 3 are supported, as may be seen from Figures 3 and 3*a*, by shafts 4, to which a rotational movement is transmitted by an electric motor 6, for example through a reduction gearing 5.

The rollers 3 are carried by cylindrical supports 4*a* which can be turned about their axes to adjust the inclination of the rollers with respect to the axis of the mandrel. The supports are fixed in their set positions with the aid of set screws 7. By the choice of this inclination, it is possible to vary the helical movement of the mandrel M (Figure 7) with respect to the guides. All the shafts of the rollers 3 may in addition be simultaneously moved towards or away from the mandrel with their rollers by well-known external kinematic connections in simple form.

The guides 1 and 2 may be fixed, or they may be rotatably mounted in bearings 8, 9 10 fixed on a common frame 50.

For the covering of the mandrel in the rear part thereof, the bearing 10 may serve as a support for rotary device 11 supporting obliquely disposed bobbins 12 which are provided with the webs or sheets A_1, A_2, etc. .... intended for covering the mandrel.

In combination with the system for the application of wound webs A_1 and A_2, or independently of this system, it is also possible with the aid of a spraying device 13 fed with material from a reservoir 14 and with air, for example, with the aid of a blower 15, to spray onto the said mandrel, for example, layers of plastic material, adhesive, or felting fibres.

In combination with the foregoing means, or independently thereof, the covering may be effected by means of a web such as A_3 emanating from a fixed installation situated close to the mandrel, which installation may comprise, for example, a carding machine, a cloth beam, a creel or other textile machine. The web thus obtained is wound on the said mandrel while being directed tangentially in relation thereto.

In an advantageous embodiment of the invention, the web A_3 may consist of a sheet of parallel filaments emanating from a creel or a beam 16 which receives filaments from bobbins 16*a* and guide combs to form a sheet of filaments 17, which may be of any nature (e.g. natural or artificial textile, or metallic filaments).

The said sheet then passes into a treatment device 18 in which the filaments may be, if desired, coated with an adhesive material to enable them to be agglomerated.

The sheet may then enter a dryer 19 and thereafter a calendering machine 20 which converts it into a web. A cooling device 21 may be provided at a point before the winding of the web A_3 on the mandrel.

For the sake of clarity in the drawing, the installation supplying the web A_3 has been shown in a vertical plane in Figure 2. In practice, such an installation, which will generally be of considerable size, will be disposed in a horizontal plane close to the ground and will generally be situated at some distance from the apparatus according to the invention.

The mandrel thus covered then passes through an apertured plate 22 on which are rotatably mounted, at the periphery of its aperture, rollers 23 which are pressed against the surface of the covered mandrel. More especially, the said rollers may be oblique and may effect by their pressure the assembly of the contiguous or overlapping helical edges of the wound webs A_1—A_n.

The cutting of the covering of the mandrel is then effected by means of knives 24 secured to the guide 1 at the forward end of the said mandrel. The said knives may be fixed or may be reciprocated to produce a sawing action. Preferably the knives 24 are circular and rotated by electric motor 25.

The knives 24 may act, as illustrated in Figure 6*a*, with a compressing action against the wall of the mandrel M to cut the covering G thereon. For this purpose, the said wall of the mandrel may be hardened. Preferably, the mandrel M comprises along cutting curves a let-in reinforcement 26 of hard material which facilitates this compressing operation.

As is shown in Figure 6*b*, the said knives 24 may also cut the covering G with a shearing action, a groove 27 of suitable form being formed in the mandrel M. The said groove may be edged with a hard lining material 28 cooperating with the edge of the knife 24 to facilitate the shearing operation.

The reinforcements, grooves or linings 26, 27, 28 occupy along the sections helical lines which must be continuously joined along the mandrel. When the pitch of these lines is equal to the length of one section, all the sections are identical and consequently interchangeable. However, if the pitch of the lines is different from the length of the sections, since the angular position of two consecutive sections is determined by their cooperating end members, these sections must be assembled in a predetermined order so that the portions of the lines may be joined from one section to the other.

Finally, there may act on the edges of the cut covering, simultaneously with the said knives, other members which exert, for example, a welding or sticking action to increase the solidity of the edges of the webs cut from the covering. More especially, the said knives may in some cases be heated

to produce both a cutting effect and a welding of the cut edges.

In the embodiment illustrated in Figure 2, two webs B_1 and B_2 are thus simultaneously cut by two diametrically opposite oblique knives 24 (see also Figure 5). These two webs are detached along tangent planes, which may be diametrically opposite, of the mandrel M. The said webs are taken up on bobbins, of which the rotated spindles 29 are also supported by the guides towards the forward end of the mandrel.

In order to ensure that the unwinding plane of the webs is fixed in relation to the guide 1, the said webs advantageously pass over rollers 96 before being wound on the bobbins of axis 29.

Thus, despite the variations in the diameter of the said bobbins, the tangent planes along which the webs are detached from the mandrel have fixed positions in relation to the guide 1. The said rollers, the axis of which is parallel to the shafts 29, may be loose or driving rollers.

When the guide 1 is held stationary, the webs B_1 and B_2 may leave the mandrel tangentially without having to be wound on bobbins. It is sufficient to exert a longitudinal pull in the direction of the said webs in order to obtain them.

However, in the majority of cases and more especially when the mandrel is covered by webs such as A_3 emanating from fixed installations, it is necessary, in order that the cutting pitch of the webs B_1 and B_2 may be sufficiently large, to turn the guide 1 simultaneously with the mandrel. In this case, the webs are taken up on bobbins supported by rotative spindles 29.

As is shown in Figure 7, the relative movement between the guide and the mandrel may be merely a translational movement (i.e. they turn at the same speed).

In this case, transversely curved webs are cut by the knives 24. Rollers 95 bring the said webs into flat form before they are wound on the bobbins 29.

Generally speaking, such rollers 95, or a pair of opposite rollers between which the web passes, may be employed to eliminate the transverse curvature of the web and if desired to bring the filaments of which they are composed into a state of tension, for example when the cutting is effected along helices of very long pitch.

It will be noted that the simultaneous supporting of the bobbins and of the knives by the guides 1, by which the constancy of the relative angular positions of the knives and of the bobbins is conveniently ensured, facilitates the construction of the device for stripping the mandrel.

In the construction illustrated in Figure 2, the sections M1, M2, etc, of the mandrel are individually made fast to one another. For this purpose, each of the said sections comprises on one of its terminal faces a centering stud 30 and at least one complementary stud 31 ensuring the angular positioning of two consecutive sections and their mutual driving. Cavities 32 and 33 respectively are formed in the opposing face of each section to receive the centering stud and the driving stud of the adjacent section.

The studs 30 and 31 may obviously be positioned in any other way provided that the opposite face of the section is formed with corresponding cavities, or may be replaced by any member adapted to join two sections end-to-end (e.g. electromagnets or suction devices).

Moreover, each section is formed with a cavity 34 in the end face on which the studs are provided, the said cavity being adapted to engage with a hook 35. The hook 35 is supported, at the forward end of the mandrel, by a disc 36 secured to a shaft 37 adapted to slide longitudinally in a support 38. The said shaft 37 is rotated by any suitable means (not shown) through a gear 39 also sliding on the said shaft and maintained in position by a right-angled bracket 40.

Disposed near to the rear of the mandrel is a similar device bearing the reference numerals 37_1—40_1, with the difference that the disc 36_1 has no hook and comprises a centering stud and a driving stud 41 instead of cavities 32_1 and 33_1 as in the disc 36.

In this construction, the longitudinal and helical advance of the mandrel may be simultaneously ensured by those of the rollers 3 which have a driving function, as indicated, and by the thrust and rotation of the shaft 37_1 at the right-hand end and the rotation and if desired the pull of the shaft 37 at the left-hand end. For this purpose, the shafts 37, 37_1 are rotated by the gearing 39, 39_1 and moved longitudinally by a mechanism (not shown), for example a cam mechanism.

When the first section M_1 of the mandrel is completely disengaged from the guide 1, the said section is separated from the mandrel by an action on the hook 35 (for example as a result of a rail 35*a* of the said hook encountering a face 38*a* of the support 38).

The section M_1 is then taken up by a semicircular cradle 42, shown in plan view in Figure 4, which is connected by its two diagonally oppositely disposed members 43 and 44 to two endless chains or cables 45 and 46. The cables 45, 46 are situated in two parallel, vertical or oblique planes which describe a rectangular circuit in the direction of the arrow 47, and pass over pulleys or pinions 48. The movement of the said chains or cables is effected with the aid of at least two of the pulleys or pinions 48 which for this purpose have a driving function.

After separation of the disc 36 and the section M_1, the cradle 42 can thus convey the

section M_1 to the rear of the mandrel, while the control of the position, and if desired the propulsion, of the said mandrel continue to be effected by the rear shaft 37_1. As soon as the section M_1 has left the forward position, the left-hand shaft 37 is reconnected to the mandrel to ensure continuity of the control of the position of the mandrel.

When the section M_1 has reached M^{111}_1, it is possible to disconnect the right-hand shaft 37_1 and to withdraw it to enable the section M_1 conveyed by the cradle 42 to remain in the position M^{111}_1 on the semi-cylindrical supports 49, the control of the position of the mandrel continuing to be effected by the left-hand shaft 37.

The rear shaft 37_1 is then moved forwards and its disc 36_1 pushes the section M_1 and thus brings it into contact with the last section of the mandrel, the rotation of the shaft 37_1 causing the studs on the disc 36_1 to descend into the cavities in the said section M_1. Continuity of the advance of the mandrel in the space used for the covering and subsequently for the stripping is thus ensured.

In the embodiment illustrated in Figure 2, the connection of the mandrel sections by inter-engagement with one another obviously limits the free span of the mandrel between the bearings by which it is supported, that is to say, the size of the lining and stripping devices, Moreover, the mandrel sections may accidentally be disengaged from one another.

These disadvantages are obviated in the embodiment illustrated in Figure 8.

In this embodiment, the mandrel sections comprise an internal screwthread and are assembled by means of a screwthreaded spindle 51. In addition, the said spindle 51, which undergoes no longitudinal movement, is intended, in addition to assembling the mandrel section, to advance the mandrel assembly, as will hereinafter be illustrated, in the direction of the arrow F by relative rotation of the said sections with respect to the said spindle.

Disposed at either end of the mandrel are bearing supports 52_1 and 52_2 adapted to be pivoted about pins 53_1 and 53_2. Rotatably mounted in each of the said supports is a tubular shaft (54_1 and 54_2) adapted to be driven by gearing (55_1 and 55_2). Each of the said tubular shafts supports a disc (56_1 and 56_2) which is adapted to slide along the said shaft by means of a spline assembly.

As in the case of Figure 2, the left-hand disc 56_1 comprises a hook for the disengagement of the mandrel section which has reached the end of its travel, and is formed with recesses to receive the studs 31 which are provided on the forward face of each of the said sections to determine the angular position of each of the said sections in relation to the preceding section. Similarly, the disc 56_2 is provided with studs which engage in the cavities in the rear face of the said sections for rotating the mandrel assembly.

Thus, the co-operating studs and recesses perform three functions: they determine the relative angular position of the consecutive sections; they ensure transmission of the rotational movement of the sections from one end of the mandrel to the other, and finally they prevent locking of the successive sections one against the other on the screw-threaded spindle 51.

The discs 56_1 and 56_2 are therefore capable of successively rotating the mandrel with respect to the spindle, and in addition, by sliding of the disc 56_1 on its shaft, of disengaging the forward section, or by sliding of the disc 56_2 on its shaft, of engaging a section at the rear of the mandrel.

Disposed coaxially within each of the shafts 54_1 and 54_2 are shafts 57_1 and 57_2, which are respectively secured to gears 58_1 and 58_2 and which are provided at the end nearer the screw with members 59_1 and 59_2 for connection to the said screw. The said connecting members may be of various forms. An embodiment thereof will be described with reference to Figure 10, which shows the details of a modification of the left-hand part of the machine illustrated in Figure 8.

By means of these coaxial shafts, it is possible, by an action exerted on one of the ends of the machine or the other, permanently to ensure relative rotation of the mandrel and of the screw for advancing the said mandrel along the said screw, which does not undergo any longitudinal displacement.

It will readily be appreciated that if the screw does not turn, the mandrel advances at each revolution by the length of the pitch of the said screw, that is to say, it accomplishes a rapid rotation with a relatively slow longitudinal advance. Such an arrangement is suitable more especially for the covering of the mandrel with the aid of fixed members, such for example as those supplying the web A_3 in Figure 2.

If, on the other hand, the screw is rapidly rotated in the unscrewing sense in relation to the sections of the mandrel, the latter can advance towards the left of the machine with a slow rotation. This arrangement is suitable in cases where the mandrel is covered by rotative members such as those supplying the webs A_1 and A_2 in Figure 2.

In both cases, the speed of rotation of the stripping device supported by the guide 1 is adapted to the speed of rotation of the mandrel for the disengagement of the cut webs B_1 and B_2.

In the embodiment illustrated in Figure 8, when the forward section is ready to be disengaged, the screw is separated from the shaft 57_1 at its forward end and the said section

is disengaged from the mandrel by the sliding of the disc 56_1.

Owing to the pivoting arrangement of the support 52_1, the said section can then be removed from the longitudinal axis of the mandrel, so that it can be conveyed towards the rear end. The said conveyance is effected by carriage 60 supporting a cradle 61 and an abutment 62. The carriage moves longitudinally on rails 63 (see Figure 9) and can be made fast by means of clips 64 and 65 either with the upper run or with the lower run of a continuous chain 66 parallel to the machine, which chain may be actuated with a continuous movement in the direction of the arrows 67.

When the mandrel section to be disengaged has been laid on the cradle 61, and the carriage 60 has been started by engagement of the clip 64 with the chain, the said section is slid off the shafts 54_1 and 57_1 by the abutment 62 and is carried towards the rear of the machine.

The support 52_2 having in turn been rocked before the arrival of the carriage 60, the abutment 62 on the advancing carriage pushes the section M_{1a} onto the shafts 54_2 and 57_2. The support 52_2 having been returned into position, the disc 56_2 sliding on its shaft then pushes the section into contact with the preceding section, and engages therein, and the screwing movement on the screwthreaded spindle 51 is resumed to effect the assembly.

It will be seen that in such a construction it is unnecessary for the shafts 54_1 and 54_2 to slide in the bearing supporting them, whereby the construction is simplified. It is sufficient for the shafts 57_1 and 57_2 to be able to slide slightly in the shafts 54_1 and 54_2 in order to be engaged with the ends of the screw 51 and be disengaged therefrom.

As will be seen from Figure 9*a*, the time during which the screw 51 and the mandrel M are separated from their driving members consisting of the shafts 54_1 and 57_1 can be reduced by giving the support 52_1 a symmetrical form comprising two diametrically opposite arms each supporting a set of shafts 54_1 and 57_1 and their driving means.

Thus, the disengagement of the front section of the mandrel takes place by means of a half-revolution of the rotary assembly 52_1, whereby one of the two sets of shafts 54_1, 57_1 is returned each time into cooperation with the ends of the mandrel and of the screw, while the disengaged section carried on the carriage 60 can be freed from these shafts by the travel of the carriage. Similarly, at the other end of the machine, the section coming from the front can be loaded onto one of the two sets of shafts 54_2, 57_2 while the other continues to drive the screw and the mandrel. Thus, the changeover of the bearing support arms can be very rapid so that it is possible without difficulty to ensure continuity of the transmission of the movement to the screw and to the mandrel. In this case, in addition, the carriage or carriages 60 can perform a continuous movement by fixture on the continuously travelling chain.

Any suitable design of mechanism in the constructions described ensure that the various operations are timed to become effective in the right sequence and for the correct duration.

In Figure 10, each of the sections consists of a nut 68 assembled by means of a flange with a spacing sleeve 69. This assembly supports a cylindrical jacket 70 which is engaged over the nut 68 and is fixed at the sleeve end by a ring 71. The ring 71 is formed with cavities 33 to receive studs 31, which are fitted in the front face of the said cylindrical jacket.

This embodiment has the following advantages:—

It is possible to make the sections with different diameters and lengths with the same nut elements 68, only the spacing sleeves and the cylindrical jackets being modified. In addition, the elements subject to wear, such as the ring 71 and the studs 31, can readily be replaced. Finally, such a section is hollow, so that it is possible to introduce therein a fluid for cooling or heating the mandrel or to provide a circulation of such a fluid through the successive sections. In this case, a packing may be provided between two consecutive sections.

The disc 56_1 is displaceable by means of a forked lever 72, the ends of which are engaged in a groove in the said disc. The opening of the hook 35, which permits the release of a section, is obtained at the end of the travel of the lever 72 towards the left by abutment of the sliding block 35*a* coupled with the said hook with an abutment ring 73 mounted on the shaft 54_1, which is not translationally movable.

In this construction, the shaft equivalent to 57_1 consists of two coaxial shafts 74 and 75 connected together against relative movement along their common axis but rotatable by a small amount with respect to one another. The shaft 74 comprises at the end nearer the screw 51 a portion 74*a* which engages in a diametrical slot 51*a* in the cylindrical end of the said screw.

The end 75*a* of the shaft 75 is formed in the manner of a flat stud adapted to engage in a cavity 51*b* in the end of the said screw 51 and to be locked in the said cavity by a quarter-turn therein. Thus, in the assembled position, the shafts 74 and 75 are connected both in rotation and in the longitudinal direction to the screw 51. The necessary movements for the assembly and detachment of the said shaft and the said screw are obtained, on the one hand, by means of a forked arm 76 effecting the simultaneous translational movement of the shafts 74 and 75 to bring the ends of the said shafts into engagement with the screw

or to disengage them therefrom, and on the other hand by the arm 77, which effects the translational movement of a sleeve 78 sliding on the end of the shaft 74, which sleeve is formed with a helical groove 78*a* adapted to turn a finger 79 fast with the inner shaft 75.

Thus, the two ends 74*a* and 75*a* are simultaneously engaged in the cavities in the end of the screw and are locked in position by rotation of 75*a* and *vice versa*.

Figure 11 shows diagrammatically the driving and control mechanisms at one of the ends of the machine of Figure 10.

Mounted loose on the shaft 53_1 supporting the pivoting support 52_1 are the gears 80 and 81 which, through the transmission systems 82 and 83 diagrammatically shown, drive the two gears 55_1 and 58_1. Thus, the pivoting of the said support does not interrupt the driving connection of the gears 55_1 and 58_1.

The gears 80 and 81 in turn receive their movement through intermediate gears such as 84 and 85. The gears 84 and 85 are mounted on separate shafts and can be rotated by a long longitudinal shaft parallel to the bench of the machine, which may serve at the same time to drive the rotary guides 1 and 2 through suitable transmission systems (not shown). Also mounted loose on the shaft 53_1 is an assembly of cams rotated by the gears 86 and 87, preferably also from the said longitudinal shaft (not shown).

This cam assembly produces the various movements which have been described with reference to Figures 8 and 10. It comprises a disc 88 formed with a non-circular groove 88*a* in which the roller 89 is movably mounted. The said roller is carried by the lever 90 which is oscillated by movement of the roller in the cam groove and which, through the link 91, effects the rocking of the pivoting support 52_1 about the shaft 53_1. It also comprises a cylinder 92 which is formed with cam grooves 92*a*, 92*b*, 92*c*. These cams act respectively on the various levers 93*a*, 93*b*, 93*c* which, through the links 94*a*, 94*b*, 94*c*, act on the forked levers 77, 76 and 72, which have been described with reference to Figure 10.

In order to permit the use of screws 51 of different pitch and length depending upon the mandrels employed, the assembly illustrated in Figure 11, as also the corresponding assembly at the other end of the machine, may be mounted in a slideway on an elongated bench. The latter may support the frames supporting the guides of the mandrel, as also the conveying device constructed, for example, as illustrated in Figure 8. In this case, the machine can be driven by a single motor through the longitudinal driving shaft, thereby simplifying the synchronisation of the various movements, and affording positive mechanical connections through gears to ensure that the mandrel is correctly positioned to receive the successive sections assembled at the rear of the mandrel.

WHAT WE CLAIM IS:—

1. Process for the continuous production of flexible webs by continuously covering with a layer of material the periphery of a mandrel consisting of a plurality of elements assembled end-to-end, the said mandrel being moved longitudinally, and cutting the said layer of material to produce a web, wherein the said mandrel elements are cylindrical in shape and coaxially aligned to form a rectilinear mandrel of cylindrical formation between the point where the mandrel is covered and the point where the layer is cut, and wherein the mandrel is moved helically about its axis, the front element being periodically detached from the mandrel and an element being periodically attached to the rear end thereof.

2. Process as claimed in Claim 1, in which the layer of material on the mandrel is cut obliquely with respect to the axis of the mandrel adjacent to where the material is cut and are moved to the other end of the mandrel.

4. Process as claimed in Claim 3, in which the element added to the said other end of the mandrel is the one which has just been removed from the front end of the mandrel.

5. Process as claimed in Claim 3 or 4, in which the elements removed from the mandrel are displaced along a path which forms three sides of a rectangle, the fourth side of which is constituted by the mandrel, the elements being displaced in such a manner that the axis of each element at any one instant is parallel with its axis at any other instant.

6. Process as claimed in any preceding claim, in which the mandrel is covered by spraying the material onto its periphery.

7. Process as claimed in any one of the preceding claims, in which the mandrel is covered with at least one strip of material applied tangentially and obliquely to the mandrel.

8. Process as claimed in Claim 7, in which the strip is fed from a stationary support.

9. Process for the continuous production of webs substantially as described with reference to the accompanying drawings.

10. Apparatus for the continuous production of webs comprising a plurality of cylindrical elements of equal diameter, means for assembling the said elements end-to-end to form a cylindrical mandrel, means for moving the said mandrel translationally along its longitudinal axis and also for rotating it about its axis, means for completely covering with a layer of material the surface of the said mandrel at the rear end with respect to the direction of its advance, means for cutting the said layer near to the forward end of the mandrel in order to detach the layer in the form of at least one web, and means for periodically detaching the front element from

the mandrel and attaching an element to the rear end thereof.

11. Apparatus according to Claim 10 in which the mandrel is mounted within at least two tubular guides one of which is disposed to the rear of the means for covering the mandrel and the other of which is disposed forwardly of the means for detaching the web, the said guides being provided internally with rollers adapted to centre and support the mandrel.

12. Apparatus according to Claim 11 comprising means for rotating the tubular guides.

13. Apparatus according to Claim 12 in which at least some of the rollers are driving rollers adapted to effect advance of the mandrel.

14. Apparatus according to any of Claims 10 to 13 in which each mandrel element is provided with a male member at one end and a female member at the other, whereby adjacent elements may be secured together.

15. Apparatus according to any of Claims 10 to 13 in which each mandrel element is provided with a male member at one end and a female member at the other, whereby adjacent elements may be secured together.

15. Apparatus according to any of Claims 10 to 13 in which the means for assembling the mandrel elements comprises at least one spindle adapted to extend through the assembly of elements.

16. Apparatus according to Claim 15 in which the spindle is provided at each of its ends with means for attaching it to devices adapted to hold the spindle in place.

17. Apparatus according to Claim 16 in which the spindle is screwthreaded over its entire length, while each of the mandrel elements comprises an axial nut adapted to be screwed on the said spindle.

18. Apparatus according to Claim 17 in which there are provided at each end of the mandrel coaxial devices for rotary and longitudinal connection respectively with the spindle.

19. Apparatus according to Claim 18 in which each of the coaxial devices comprises a tubular shaft, provided with means adapted to co-operate with the mandrel element at the corresponding end of the mandrel, and an inner shaft adapted to engage the corresponding end of the spindle in a fixed longitudinal position of the said spindle.

20. Apparatus according to Claim 18 in which the coaxial devices are carried by supports adapted to pivot about axes parallel to that of the mandrel, the devices being adapted to carry a mandrel element.

21. Apparatus according to any of Claims 10—20 comprising rotary device turning about the mandrel and supporting bobbins for the covering material.

22. Apparatus according to any of Claims 10—21 in which pressure rollers are applied against the periphery of the covered mandrel adjacent the covering device.

23. Apparatus according to any of Claims 10—22 in which the mandrel is provided internally with means adapted to modify the temperature of the mandrel, whereby a thermal treatment of the covering may be effected.

24. Apparatus according to any of Claims 10—23 comprising a rotative circular blade by means of which the covering of the mandrel may be cut against the latter.

25. Apparatus according to Claim 24 in which the blade is adapted to cut the covering by compression of the latter against the wall of the mandrel.

26. Apparatus according to Claim 24 in which the blade is adapted to shear the covering by co-operating with a groove formed in the wall of the mandrel.

27. Apparatus according to Claims 11 and 24 in which the blade cutting the web and the spindle of a bobbin on which the said web is wound, are supported by one of the tubular guides.

28. Apparatus according to Claim 27 comprising at least one roller disposed perpendicular to the longitudinal axis of the said web before it is wound on the bobbin, the roller being so disposed that the web contacts the roller after it is cut.

29. Apparatus for the continuous production of flexible webs substantially as described with reference to and as shown in the accompanying drawings.

30. A continuous flexible web made by the process according to any of Claims 1—9 or by the apparatus according to any of Claims 10—29.

31. A web according to Claim 30 comprising parallel reinforcements oblique in relation to the edges of the web, the said reinforcements being agglomerated by at least one adhesive material.

32. A web according to Claim 31 comprising at least three superposed layers of reinforcement, the directions of which intersect one another.

33. A web according to Claim 30 comprising woven filaments.

34. A web according to Claim 30 comprising transverse zones of different natures.

35. A web according to Claim 30 formed of short matted and agglomerated fibres.

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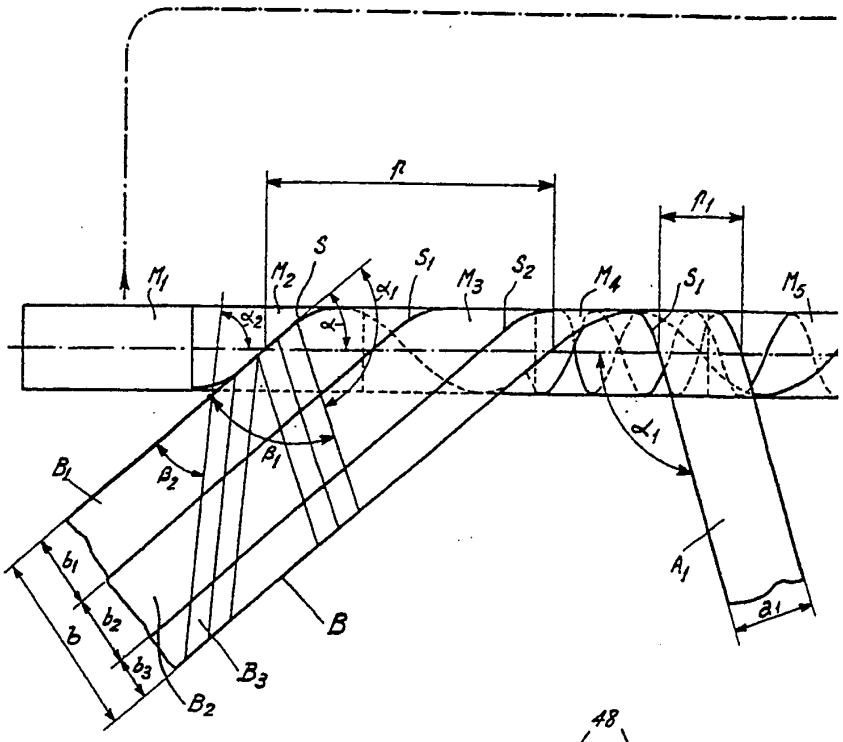
9, Staple Inn, London, W.C.1.

Leamington Spa: Printed for Her Majesty's Stationery Office, by the Courier Press.—1960.
Published at The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained

Fig.1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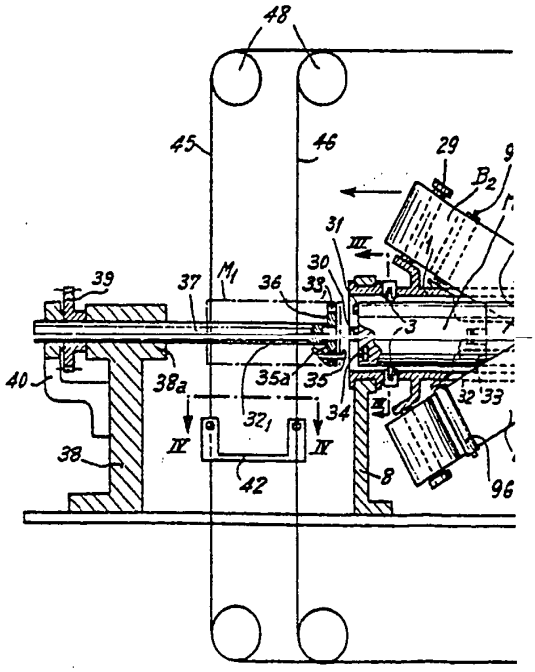
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Fig. 1

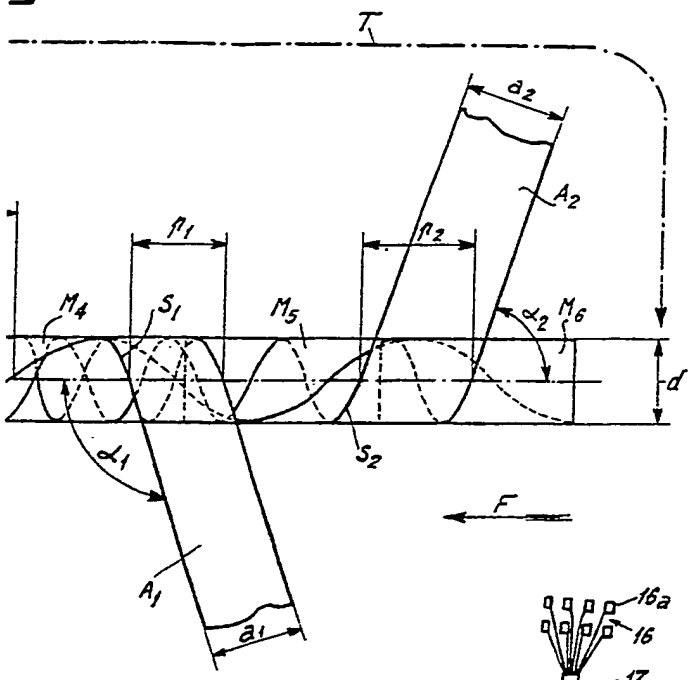
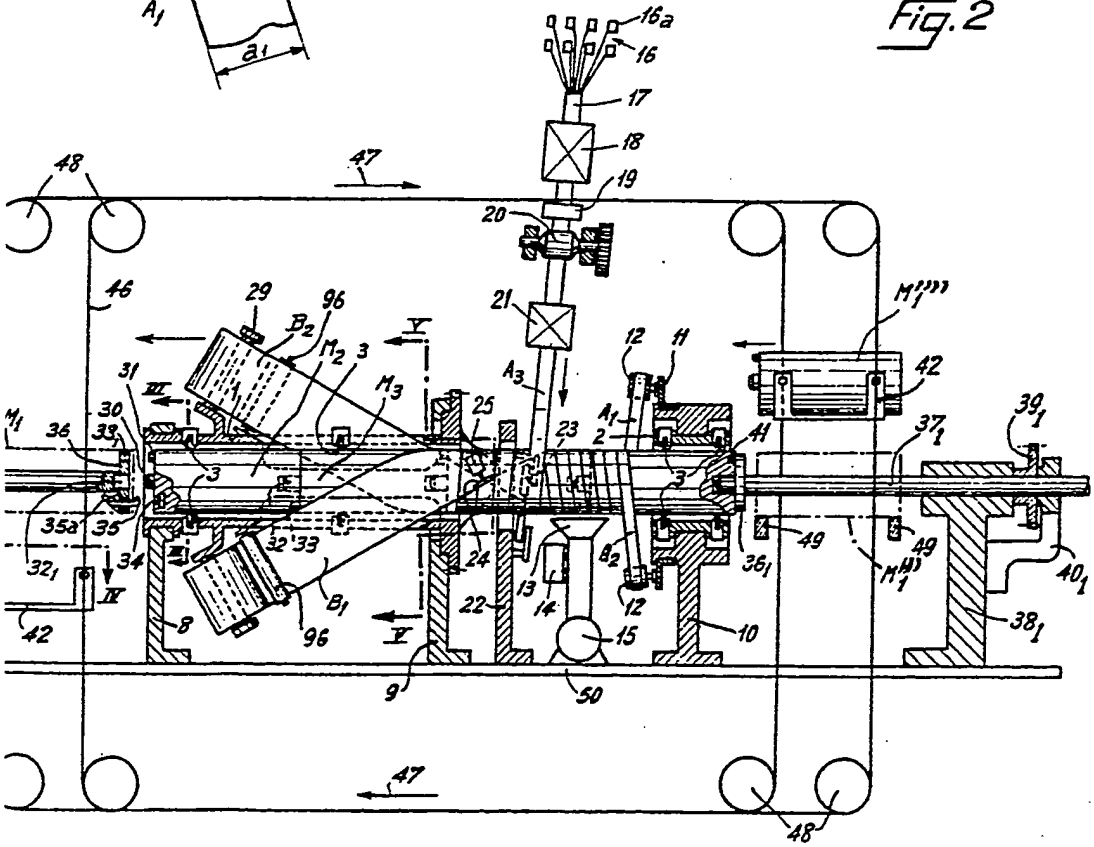


Fig. 2



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SHEET 1

Fig. 1

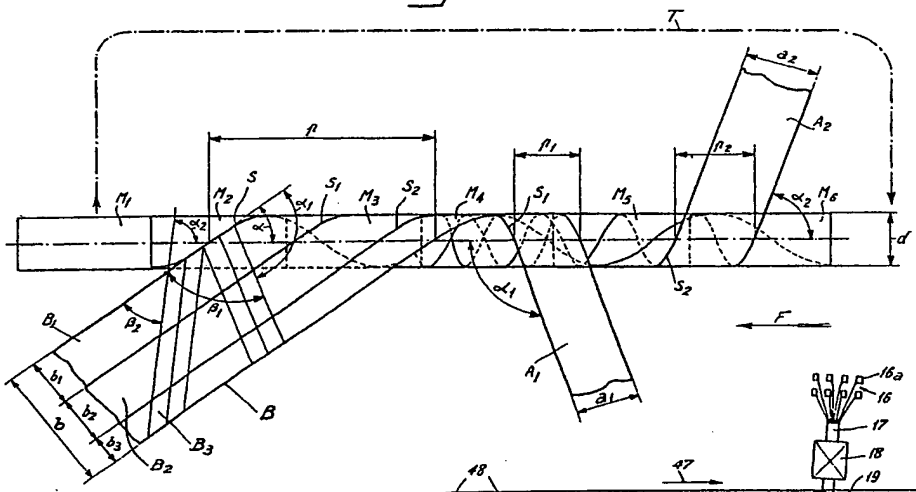

Fig. 2

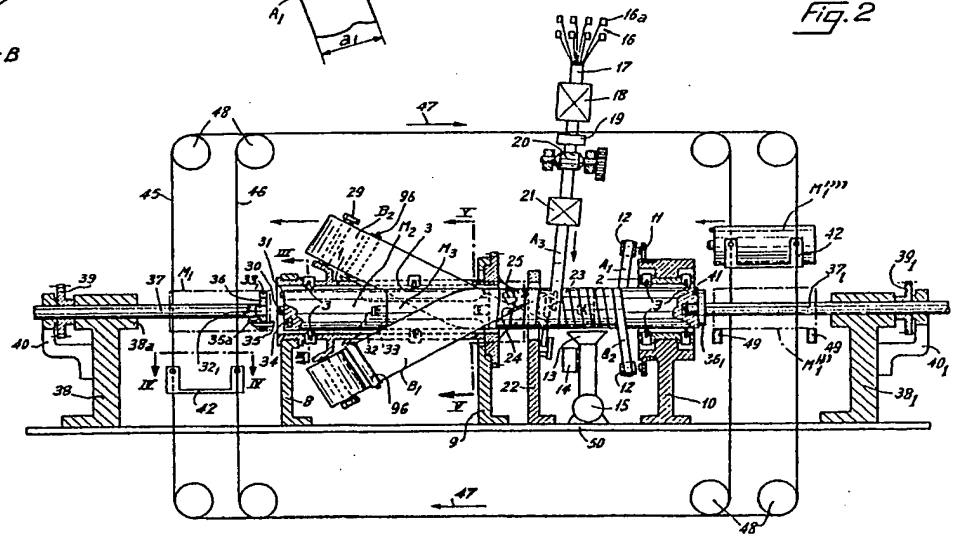

Fig. 1a

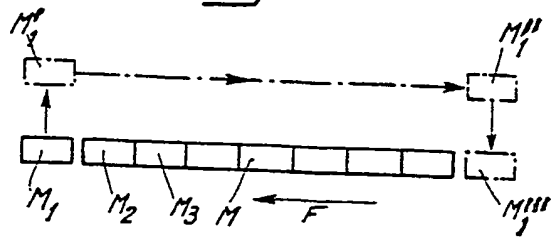

Fig. 1b

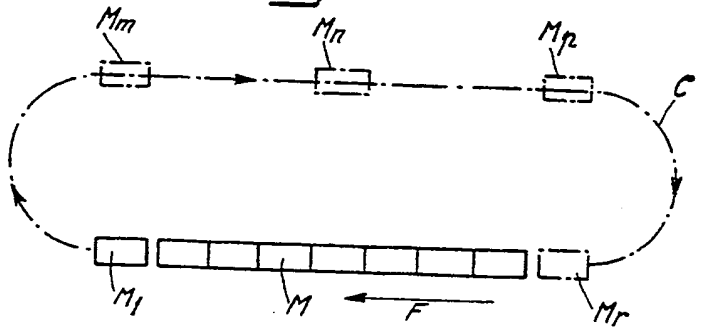

Fig. 1c

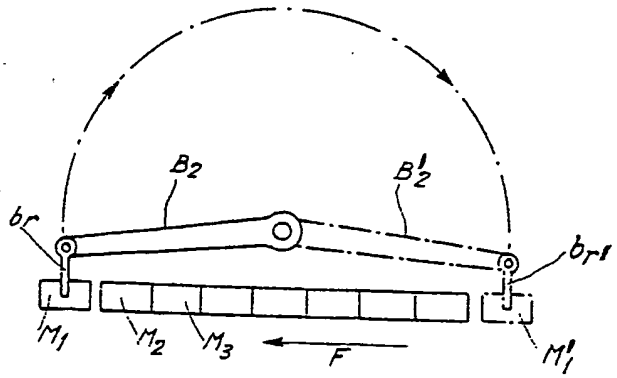

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Fig. 3

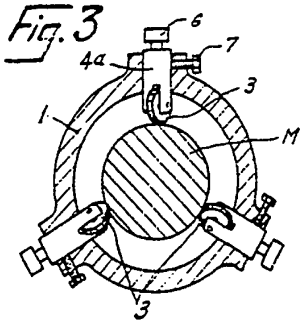


Fig. 4

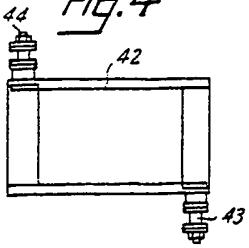


Fig. 6a

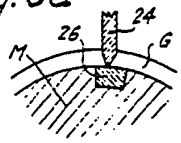


Fig. 6b

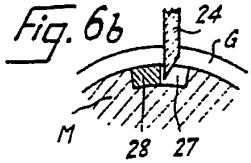


Fig. 3a

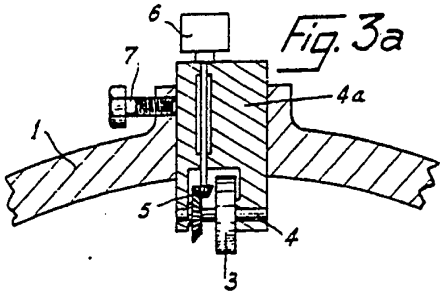


Fig. 5

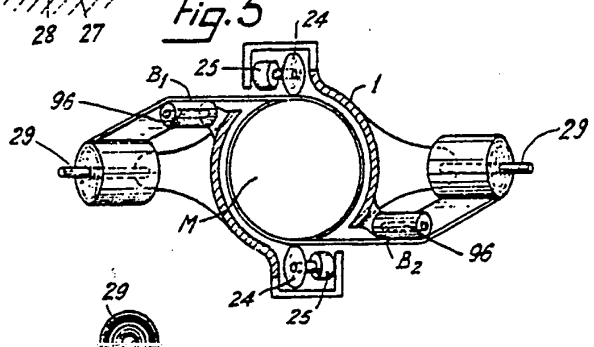
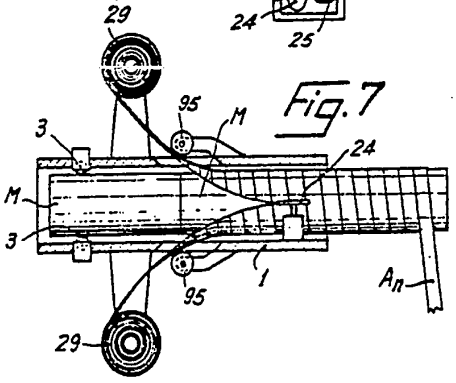


Fig. 7



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SHEETS 2 & 3

Fig. 1a

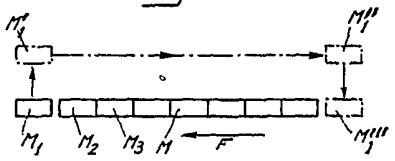


Fig. 1b

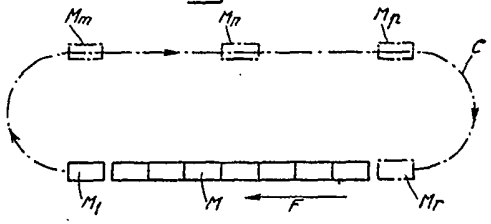


Fig. 1c

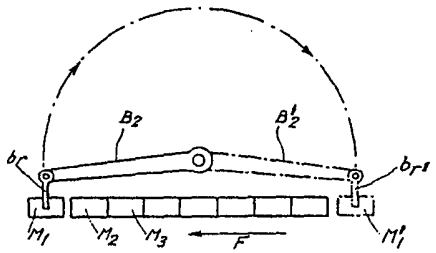


Fig. 3

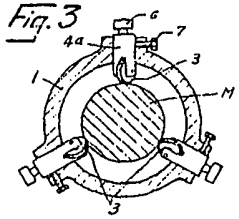


Fig. 4

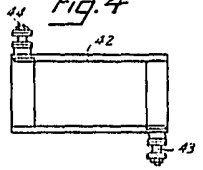


Fig. 6a

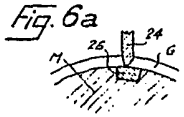


Fig. 6b

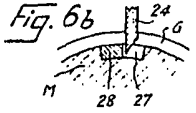


Fig. 3a

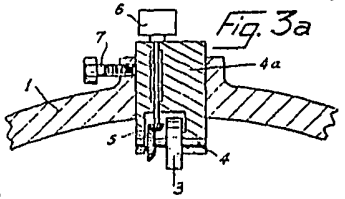


Fig. 5

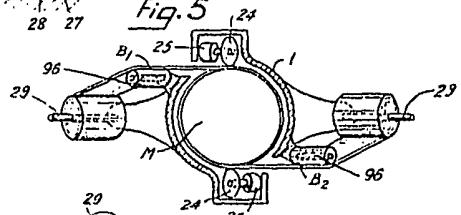
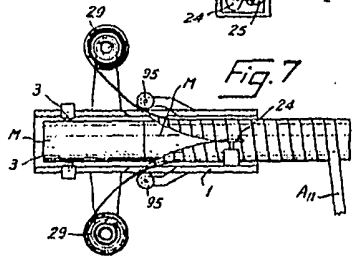


Fig. 7



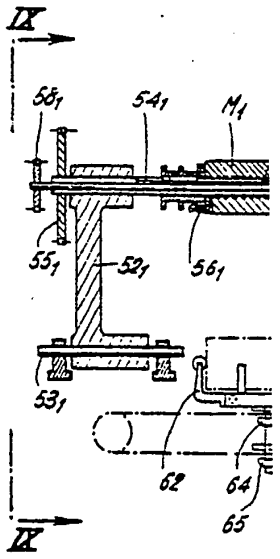


Fig. 9

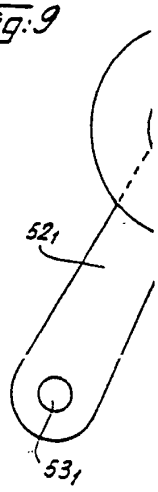


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Fig.8

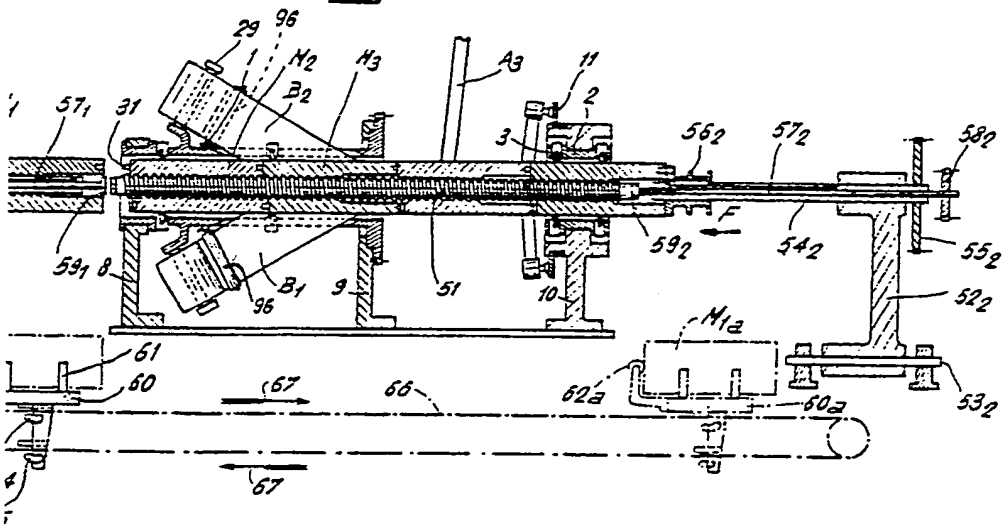

Fig.9a

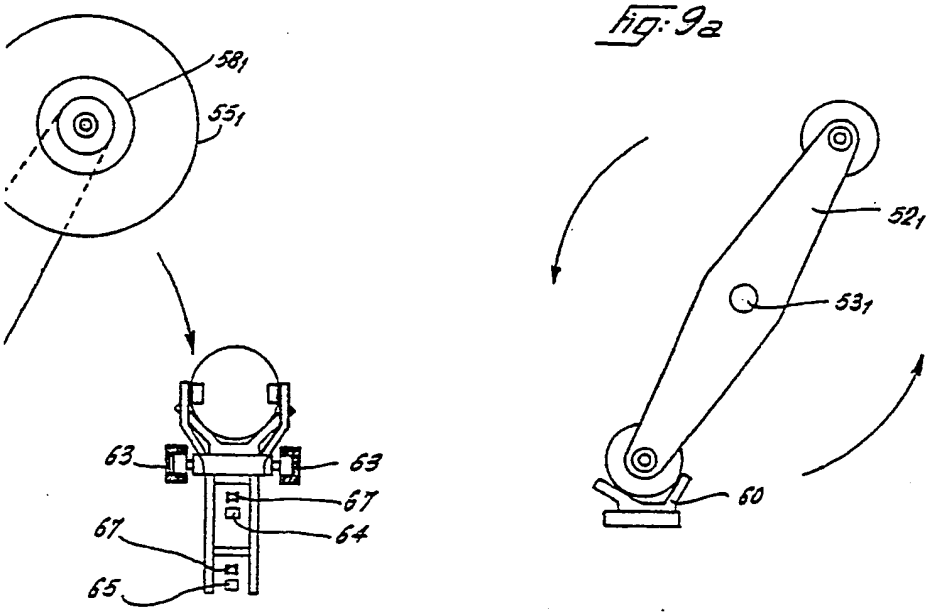

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Fig.8

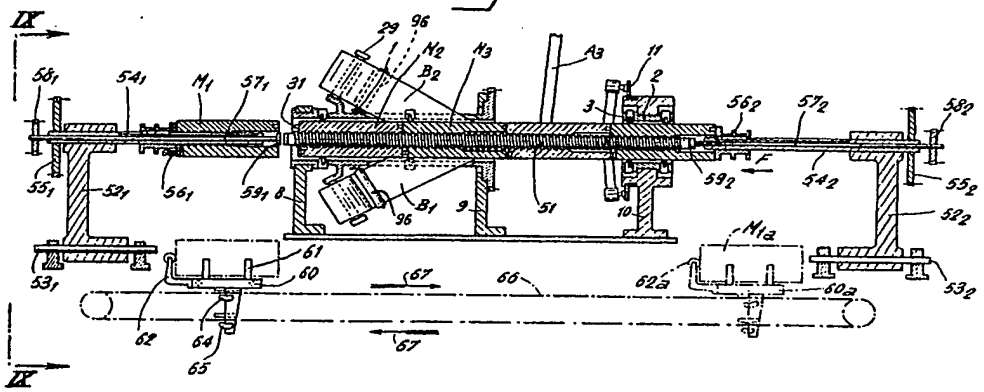


Fig:9

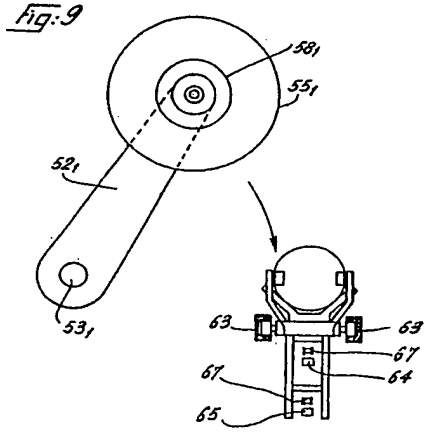
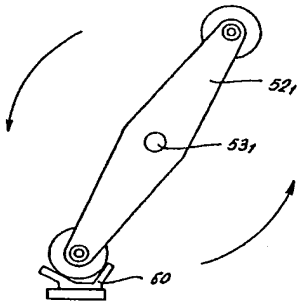


Fig:9a



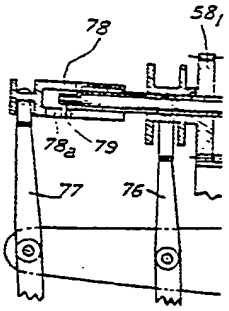
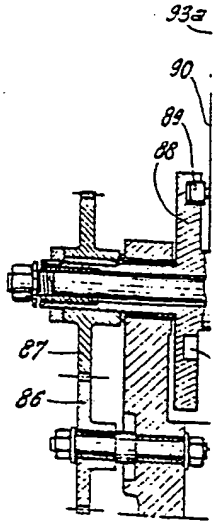
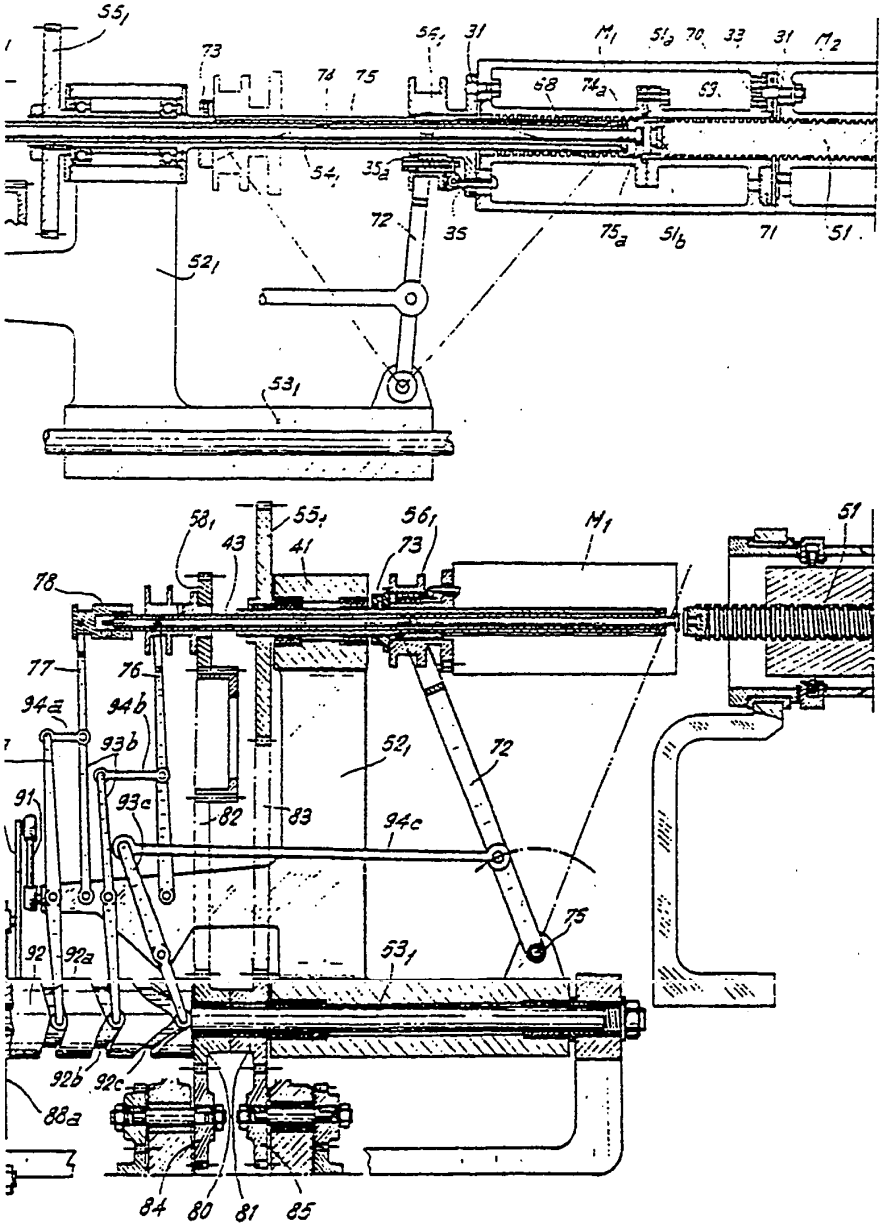


Fig: 11



844,536 COMPLETE SPECIFICATION
5 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEET 5

Fig. 10



844.536 COMPLETE SPECIFICATION
5 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEET 5

Fig:10

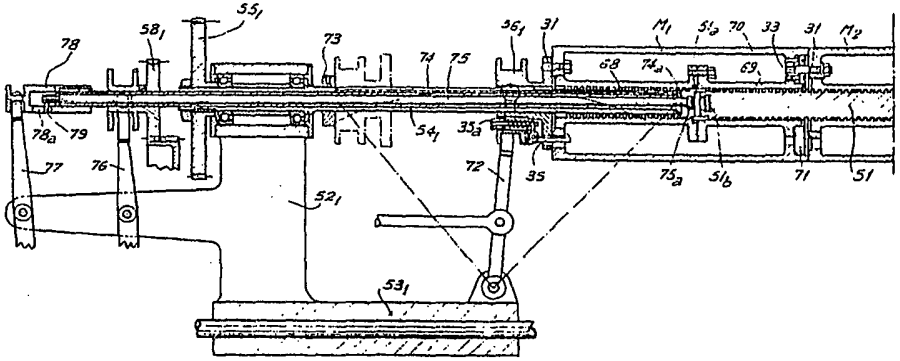


Fig:11